

SCOPE OF CLAIMS

5 1. A display device comprising:  
an optical waveguide plate for introducing light  
thereinto;  
an actuator substrate provided opposingly to one plate  
surface of said optical waveguide plate and arranged with  
actuator elements of a number corresponding to a large  
number of pixels;  
a pixel structure formed on each of said actuator  
elements of said actuator substrate; and  
a crosspiece formed at a portion other than said pixel  
structure between said optical waveguide plate and said  
actuator substrate.

10  
15  
20 2. The display device according to claim 1, wherein  
said actuator element includes a shape-retaining layer, an  
operating section having at least a pair of electrodes  
formed on said shape-retaining layer, a vibrating section  
for supporting said operating section, and a fixed section  
for supporting said vibrating section in a vibrating manner.

25 3. The display device according to claim 1 ~~or 2~~,  
wherein said crosspiece is secured to said optical waveguide  
plate.

4. The display device according to claim 1 ~~or 2~~,

wherein a gap-forming layer is provided between said optical waveguide plate and said crosspiece.

claim 1

5 9 5. The display device according to ~~any one of claims 1 to 4~~, wherein said crosspiece is formed at portions around four corners of each of said pixel structure.

claim 1

11 9 6. The display device according to ~~any one of claims 1 to 5~~, wherein said crosspiece has a window for surrounding at least one pixel structure.

claim 1

15 9 7. The display device according to ~~any one of claims 1 to 5~~, wherein said crosspiece includes a stripe-shaped opening which extends along a direction of an array of said pixel structures and which surrounds said array of said pixel structures.

claim 1

20 9 8. The display device according to ~~any one of claims 1 to 5~~, wherein said crosspiece is formed to have a line-shaped configuration which extends along a direction of an array of said pixel structures.

claim 1

25 9 9. The display device according to ~~any one of claims 1 to 8~~, wherein said crosspiece is formed integrally with said actuator substrate.

claim 1

9 10. The display device according to ~~any one of claims~~

Q ~~1 to 8~~, wherein said crosspiece is constructed by a wire member which extends along a direction of an array of said pixel structures.

5 Q <sup>claim 1</sup> 11. The display device according to ~~any one of claims~~  
Q ~~1 to 10~~, wherein a recess is formed on a surface of said pixel structure.

Q <sup>claim 1</sup> 12. The display device according to ~~any one of claims~~  
Q ~~1 to 11~~, wherein a step is formed on a surface of said pixel structure.

Q <sup>claim 1</sup> 13. The display device according to ~~any one of claims~~  
Q ~~1 to 12~~, wherein a surface of said pixel structure has a concave configuration.

11 14. A method for producing a display device, comprising:

20 29 a crosspiece-forming step of forming a plurality of crosspieces at portions other than actuator elements, of an actuator substrate arranged with said actuator elements corresponding to a large number of pixels;

25 a pixel-forming step of forming pixel structures on said respective actuator elements on said actuator substrate; and

a pressurizing step of laminating and pressurizing an optical waveguide plate in a state in which at least said

pixel structures are not hardened, and then hardening at least said pixel structures.

5           15.   A method for producing a display device,  
comprising:

          a crosspiece-forming step of forming a plurality of crosspieces at portions other than portions corresponding to a large number of actuator elements, of an optical waveguide plate;

10           a pixel-forming step of forming pixel structures at portions corresponding to said large number of pixels, of said optical waveguide plate; and

15           a pressurizing step of laminating an actuator substrate arranged with actuator elements of a number corresponding to said large number of pixels, on said crosspieces and said pixel structures, and pressurizing said optical waveguide plate and said actuator substrate in directions to make approach to one another.

20           16.   A method for producing a display device,  
comprising:

          a crosspiece-forming step of forming a plurality of crosspieces at portions other than actuator elements, of an actuator substrate arranged with said actuator elements  
25           corresponding to a large number of pixels;

          a pixel-forming step of forming pixel structures at portions corresponding to said large number of pixels, of an

~~optical waveguide plate; and~~

5 a pressurizing step of laminating a surface of said actuator substrate formed with said crosspieces and a surface of said optical waveguide plate formed with said pixel structures with each other, and pressuring said optical waveguide plate and said actuator substrate in directions to make approach to one another.

10 17. A method for producing a display device, comprising:

a crosspiece-forming step of forming a plurality of crosspieces at portions other than portions corresponding to a large number of actuator elements, of an optical waveguide plate;

15 a pixel-forming step of forming pixel structures on respective actuator elements of an actuator substrate arranged with said actuator elements of a number corresponding to said large number of pixels; and

20 a pressurizing step of laminating a surface of said actuator substrate formed with said pixel structures and a surface of said optical waveguide plate formed with said crosspieces with each other, and pressuring said optical waveguide plate and said actuator substrate in directions to make approach to one another.

25 18. A method for producing a display device, comprising:

5 a pixel-forming step of forming pixel structures on  
respective actuator elements of an actuator substrate  
arranged with said actuator elements of a number  
corresponding to a large number of pixels and integrally  
having a plurality of crosspieces at portions other than  
said actuator elements; and

10 a pressurizing step of laminating and pressurizing an  
optical waveguide plate in a state in which at least said  
pixel structures are not hardened, and then hardening at  
least said pixel structures.

15 19. A method for producing a display device,  
comprising:

20 a crosspiece-forming step of forming a plurality of  
crosspieces at portions other than actuator elements, of an  
actuator substrate arranged with said actuator elements of a  
number corresponding to a large number of pixels;

a pixel-forming step of forming pixel structures on  
said respective actuator elements of said actuator  
substrate;

a first laminating step of laminating a plate member in  
a state in which at least said pixel structures are not  
hardened;

25 a pressurizing step of pressurizing said actuator  
substrate and said plate member in directions to make  
approach to one another, and then hardening at least said  
pixel structures; and

a second laminating step of removing said plate member, and then laminating an optical waveguide plate at least on said crosspieces.

5           20. A method for producing a display device, comprising:

a crosspiece-forming step of forming a plurality of crosspieces at portions other than portions corresponding to a large number of pixels, of a plate member;

10           a pixel-forming step of forming pixel structures at said portions corresponding to said large number of pixels, of said plate member;

15           a first laminating step of laminating an actuator substrate arranged with actuator elements of a number corresponding to said large number of pixels on said crosspieces and said pixel structures;

20           a pressurizing step of pressurizing said plate member and said actuator substrate in directions to make approach to one another; and

25           a second laminating step of removing said plate member to transfer said crosspieces and said pixel structures to said actuator substrate, and then laminating an optical waveguide plate on at least said crosspieces.

25           21. A method for producing a display device, comprising:

a crosspiece-forming step of forming a plurality of

crosspieces at portions other than actuator elements, of an actuator substrate arranged with said actuator elements of a number corresponding to a large number of pixels;

5 a pixel-forming step of forming pixel structures at portions corresponding to said large number of pixels, of a plate member;

a first laminating step of laminating a surface of said actuator substrate formed with said crosspieces and a surface of said plate member formed with said pixel structures with each other;

10 a pressurizing step of pressurizing said plate member and said actuator substrate in directions to make approach to one another; and

15 a second laminating step of removing said plate member to transfer said pixel structures to said actuator substrate, and then laminating an optical waveguide plate on at least said crosspieces.

20 22. A method for producing a display device, comprising:

a pixel-forming step of forming pixel structures on respective actuator elements of an actuator substrate arranged with said actuator elements of a number corresponding to a large number of pixels;

25 a crosspiece-forming step of forming a plurality of crosspieces at portions other than portions corresponding to said large number of pixels, of a plate member;



~~a first laminating step of laminating a surface of said~~  
actuator substrate formed with said pixel structures and a  
surface of said plate member formed with said crosspieces  
with each other;

5           a pressurizing step of pressurizing said plate member  
and said actuator substrate in directions to make approach  
to one another; and

          a second laminating step of removing said plate member  
to transfer said crosspieces to said actuator substrate, and  
then laminating an optical waveguide plate on at least said  
crosspieces.

23. A method for producing a display device,  
comprising:

10           a pixel-forming step of forming pixel structures on  
respective actuator elements of an actuator substrate  
arranged with said actuator elements of a number  
corresponding to a large number of pixels and integrally  
having a plurality of crosspieces at portions other than  
20           said actuator elements;

          a first laminating step of laminating a plate member in  
a state in which at least said pixel structures are not  
hardened;

25           a pressurizing step of pressurizing said actuator  
substrate and said plate member in directions to make  
approach to one another, and then hardening at least said  
pixel structures; and

~~a second laminating step of removing said plate member,~~  
and then laminating an optical waveguide plate on at least  
said crosspieces.

5           24. A method for producing a display device,  
comprising:

10           a pixel-forming step of forming pixel structures on  
respective actuator elements of an actuator substrate  
arranged with said actuator elements of a number  
corresponding to a large number of pixels;

15           a first laminating step of using a jig including, on  
one surface of a plate member, a large number of size-  
defining members formed to have substantially the same  
height as that of crosspieces to be formed on said actuator  
substrate to laminate a surface of said jig formed with said  
size-defining members and a surface of said actuator  
substrate formed with said pixel structures with each other;

20           a pressurizing step of pressurizing said jig and said  
actuator substrate in directions to make approach to one  
another;

          a crosspiece-forming step of removing said jig, and  
then forming said plurality of crosspieces at portions other  
than said actuator sections, of said actuator substrate; and

25           a second laminating step of laminating an optical  
waveguide plate on at least said crosspieces on said  
actuator substrate.

25. A method for producing a display device,  
comprising:

5 a pixel-forming step of forming pixel structures on  
respective actuator elements of an actuator substrate  
arranged with said actuator elements of a number  
corresponding to a large number of pixels;

10 a first laminating step of using a jig including, on  
one surface of a plate member, a large number of size-  
defining members formed to have substantially the same  
height as that of crosspieces to be formed on said actuator  
substrate to laminate a surface of said jig formed with said  
size-defining members and a surface of said actuator  
substrate formed with said pixel structures with each other;

15 a pressurizing step of pressurizing said jig and said  
actuator substrate in directions to make approach to one  
another;

20 a crosspiece-forming step of removing said jig, and  
then forming said plurality of crosspieces at portions other  
than portions corresponding to said large number of pixels,  
of an optical waveguide plate; and

25 a second laminating step of laminating a surface of  
said actuator substrate formed with said pixel structures  
and a surface of said optical waveguide plate formed with  
said crosspieces with each other.

26. A method for producing a display device,  
comprising:

~~a pixel-forming step of forming pixel structures on~~  
respective actuator elements of an actuator substrate  
arranged with said actuator elements of a number  
corresponding to a large number of pixels;

5           a crosspiece-forming step of using a jig including, on  
one surface of a plate member, a large number of size-  
defining members formed to have substantially the same  
height as that of crosspieces to be formed on said actuator  
substrate to form said plurality of crosspieces at portions  
10           formed with no size-defining member, of a surface of said  
jig formed with said size-defining members, said portions  
being other than portions corresponding to said large number  
of pixels;

15           a first laminating step of laminating said surface of  
said jig formed with said size-defining members and said  
crosspieces and a surface of said actuator substrate formed  
with said pixel structures with each other;

20           a pressurizing step of pressurizing said jig and said  
actuator substrate in directions to make approach to one  
another; and

25           a second laminating step of removing said jig to  
transfer said crosspieces to said actuator substrate, and  
then laminating an optical waveguide plate on at least said  
crosspieces on said actuator substrate.

27. A method for producing a display device,  
comprising:

~~a crosspiece-forming step of forming a plurality of~~  
crosspieces at portions other than actuator elements, of an  
actuator substrate arranged with said actuator elements of a  
number corresponding to a large number of pixels;

5           a pixel-forming step of forming pixel structures on  
said respective actuator elements of said actuator  
substrate;

10           a first laminating step of using a jig including, on  
one surface of a plate member, a large number of size-  
defining members formed to have substantially the same  
height as that of said crosspieces to be formed on said  
actuator substrate to laminate a surface of said jig formed  
with said size-defining members and a surface of said  
actuator substrate formed with said crosspieces and said  
15 pixel structures with each other;

20           a pressurizing step of pressurizing said jig and said  
actuator substrate in directions to make approach to one  
another; and

25           a second laminating step of removing said jig, and then  
laminating an optical waveguide plate on at least said  
crosspieces on said actuator substrate.

28. A method for producing a display device,  
comprising:

25           a crosspiece-forming step of forming a plurality of  
crosspieces at portions other than actuator elements, of an  
actuator substrate arranged with said actuator elements of a

~~number corresponding to a large number of pixels;~~

5 a pixel-forming step of using a jig including, on one surface of a plate member, a large number of size-defining members formed to have substantially the same height as that of said crosspieces to be formed on said actuator substrate to form pixel structures at portions corresponding to said large number of pixels, said portions being formed with no size-defining member, of a surface of said jig formed with said size-defining members;

10 a first laminating step of laminating said surface of said jig formed with said size-defining members and said pixel structures and a surface of said actuator substrate formed with said crosspieces with each other;

15 a pressurizing step of pressurizing said jig and said actuator substrate in directions to make approach to one another; and

20 a second laminating step of removing said jig to transfer said pixel structures to said actuator substrate, and then laminating an optical waveguide plate on at least said crosspieces on said actuator substrate.

29. A method for producing a display device, comprising:

25 a crosspiece-forming step of using a jig including, on one surface of a plate member, a large number of size-defining members formed to have substantially the same height as that of crosspieces to be formed on an actuator

substrate to form said plurality of crosspieces at portions  
formed with no size-defining member, of a surface of said  
jig formed with said size-defining members, said portions  
being other than portions corresponding to a large number of  
pixels;

a pixel-forming step of forming pixel structures at  
portions corresponding to said large number of pixels, said  
portions being formed with no size-defining member, of said  
surface of said jig formed with said size-defining members;

a first laminating step of laminating said actuator  
substrate arranged with actuator elements of a number  
corresponding to said large number of pixels on said  
crosspieces and said pixel structures on said jig;

a pressurizing step of pressurizing said jig and said  
actuator substrate in directions to make approach to one  
another; and

a second laminating step of removing said jig to  
transfer said crosspieces and said pixel structures to said  
actuator substrate, and then laminating an optical waveguide  
plate on at least said crosspieces.

30. The method for producing said display device  
according to claim 20, ~~22, 23, 26, or 29~~, wherein when said  
crosspieces are formed, said members for constructing said  
crosspieces are laminated by utilizing surface tension of  
liquid.

31. The method for producing said display device according to claim 20, 22, 25, 26, or 29, wherein said crosspiece-forming step comprises forming said crosspieces at said concerning portions of said plate member, and then hardening said crosspieces.

32. The method for producing said display device according to <sup>claim 14</sup> ~~any one of claims 14 to 31~~, wherein said pressurizing step comprises hardening at least said pixel structures while pressurizing said actuator substrate and said member to be pressurized together with said actuator substrate.

33. The method for producing said display device according to <sup>claim 14</sup> ~~any one of claims 14 to 32~~, wherein said optical waveguide plate includes a gap-forming layer at a portion corresponding to said crosspiece.

34. The method for producing said display device according to <sup>claim 14</sup> ~~any one of claims 14 to 32~~, wherein a gap-forming layer is previously formed on said crosspiece before laminating said optical waveguide plate.

35. The method for producing said display device according to <sup>claim 14</sup> ~~any one of claims 14 to 34~~, wherein when said actuator substrate and said member to be pressurized together with said actuator substrate are pressurized, a



preliminary treatment is performed for gap formation, and a predetermined gap is formed between said pixel structure and said optical waveguide plate during said hardening of at least said pixel structures performed thereafter.

5

36. The method for producing said display device according to <sup>claim 14</sup> ~~any one of claims 14 to 35~~, wherein a vacuum packaging method is used to pressurize said actuator substrate and said member to be pressurized together with said actuator substrate.

37. The method for producing said display device according to <sup>claim 14</sup> ~~any one of claims 14 to 35~~, wherein a low pressure press method is used to pressurize said actuator substrate and said member to be pressurized together with said actuator substrate.

38. The method for producing said display device according to <sup>claim 19</sup> ~~any one of claims 19 to 37~~, wherein:

said member, which is used to be laminated on said actuator substrate in said first laminating step, has a projection at a portion corresponding to each of said pixel structures; and

a recess corresponding to said projection is formed on said surface of said pixel structure upon said pressurization performed in said pressurizing step after said first laminating step.

39. The method for producing said display device  
according to <sup>claim 19</sup> ~~any one of claims 19 to 38~~, wherein:

said member, which is used to be laminated on said actuator substrate in said first laminating step, has a projection at a portion corresponding to each of said pixel structures; and

a step corresponding to said projection is formed on said surface of said pixel structure upon said pressurization performed in said pressurizing step after said first laminating step.

40. The method for producing said display device  
according to <sup>claim 19</sup> ~~any one of claims 19 to 39~~, wherein:

said member, which is used to be laminated on said actuator substrate in said first laminating step, has a convex configuration formed at a portion corresponding to each of said pixel structures; and

a concave configuration corresponding to said convex configuration is formed on said surface of said pixel structure upon said pressurization performed in said pressurizing step after said first laminating step.